Study of Interoperability and Cloud Integration in Internet of Things

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SYNOPSIS

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1. INTRODUCTION

Integrated technologies in the IoT portfolio enable smart usage of data. It leverages the world & provides degree of automation in computing paradigm of IoT that led to the future of smart world. The Multiplatform integration and its interoperability is also a major concern in shaping future of IoT world. A place where actual IoT magic happens must enhances the productivity; enables the technologies to come together rapidly, and automate applications and services to support real-time monitoring and achieving interoperability. This synopsis shed light on major concern and objectives of interoperability of Cloud-IoT platform integration where diverse systems and applications are becoming capable to work together and achieve a smart digital future objective.

IoT has transformed the world into digital portfolio with smart homes, smart buildings, smart manufacturing and industrial plants, smart medicine and healthcare, smart safety and security, smart insurance, smart transport, smart energy and smart meters (water, electricity, gas), etc. [1]. It is a technology that works with the communication network and based on IP between electronic devices and sensors [2]. It empowers collaboration from anywhere; becomes an important aspect of life that can support and facilitates devices and users. It is an advanced technology and takes advantage of data processing at edges nodes or remote server within integrated manner. The example of such computing is Green computing in terms of environment, processing speed in terms of 5G; which were not conceivable earlier [3].

For the intelligence and interconnection, it referred as pool of technology. Deploying and managing applications in a IoT scenario can be challenging, costly, and time consuming—especially when real time offloading and security is a concern; but the multi-platform integration paradigm enables you to increase your working margins, security of your data, and reduce downtime while rapidly deploy applications. [4] The recent advancement in IoT is comprised of parallel oriented platforms for Things. Developers who want to use them need to negotiate access individually and it is necessary to adapt to the platform-specific API and information models.

2. Cloud Computing

Automation and application are the future proof for IT world. The cloud, with its design, allows powerful and expensive systems, and roll out an entire corporate landscape with no human

interaction. It has an enormous growth to deploy and maintain software and is being meet infinite demands of industries widely. [5] It defines a paradigm, in which real time scalable resources and third party services allows to access using the internet. It is the technological model; to use IT infrastructures and provide services by the help of web apps and becomes an appropriate resource [6]. Even though there are numerous variations on the functions of Cloud Computing; it provides technological capabilities such as act tactical enabler, provide simplified management, align loads, broad Network Access, Resource Pooling and innovative acceleration.

Cloud computing is a model that relies on shipping high volumes; has a very simple concept that can leverage competitive advantage in the IoT. A simple explanation for cloud computing is delivery of different services such as servers, storage, networking, databases, software analytics, intelligence using virtual pool of resources via the Internet, it is available anywhere via net enabled services. The essence of cloud computing is utility computing. The information being accessed is found in the 'clouds' and covers whole range of applications, from monitoring, metering, sensing, to actuating in an IoT scenario. Companies are not required to own their own servers and can use capacity leased from third parties; in addition, executed carefully designed automation strategies and energy-saving plans. It enables to create future-ready innovations across all of leased environments using the newest technologies. The recent sparks in cloud collaboration with IoT solution not only focused on telemetry and data collection from devices but also to fulfil complex scenario, for supporting the business needs. Its new infrastructure is upgrading and comprises many cloud components in terms of automation, smart service design, software changes adoptability, easy to operate etc. engineered to leverage the power of cloud resources to make the environment resilient to solve business needs constraints. In a traditional design environment, you'll connect your database to modules, and those modules will connect with a web app but as new demands are approaching the environment at a high level, new cloud-native architecture needs; that allows adaptive and agile development of new services with very different set of architectural constraints offered by the cloud compared to traditional application and services. It defines the components as well as the relationships between them and should be largely self-healing, cost efficient, dynamically orchestrated and easily updated and maintained through service-oriented and event-driven strategies.

2.1. Cloud Evolution

In the last two decades the cloud and its cooperative models have major transformation from cloud based to micro services and server less architecture as per the applications needed. The deep insight about these transformation is as follows:

Monolithic Cloud Hosting Architecture

The services of cloud computing hosting by the first decade of the 21st century. These three tier application use cases require functionality in applications such that; they must support distributed computing, network coverage, huge data storage and efficient computation etc. The consumers used the resources as per the need. These architectures follow all in one competences with multiple versions and offered three different functional areas illustrate in Figure 1:

Infrastructure as a service (IaaS): This one is most malleable from all three flavors of services, but act as a pay-as-per model; and allows to outsource IT infrastructure preferable are hardware, Operating System, and network coverage.

Platform as a service (PaaS): This service of cloud computing offers platform to their clients for offering to run different business applications; thus the cloud developers does not need to worry about all the server infrastructure, network, and monitoring tasks.

Software as a service (SaaS): SaaS is a software distribution Model; that connects users to use software applications without knowing the application codes. This model offers many opportunities but sometimes inflexible when the client needs to choose random and custom business functions that does not provide by service providers.

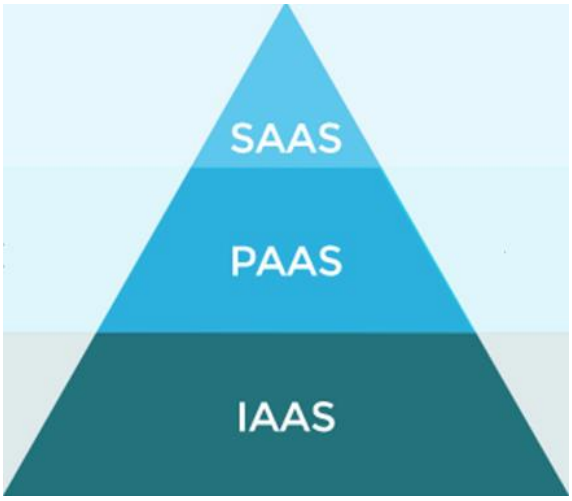


Figure 1: Cloud Hosting Services

Micro Service Cloud Architecture

It is an extended architectural concept with cluster of micro services; in which the developers extend and upgrade the codes to add more functionalities without disrupting the other part of software model. The services can also be scaled up or down based on demand, at the individual service level. It is best suited for applications where no need to develop the code from scratch but used contract-driven development between service providers and service consumers. This architecture has advantage to less time development and no dependency of teams with each other.

Server less Cloud Architecture

A hot trend that revolutionized the world and gain a lot of attention in the last few years is server less architecture. This architecture also well known as server less computing. Server less computing is a step further than the PaaS model. In this model an illusion has been created, originally for the benefits of developers whose business services hosted at cloud; and extended the way people use it.

These backend services provide clients a platform to write and deploy codes without the worrying of underlying infrastructure; and to pay on the basis of computation done instead of fixed charge. The backbone of this computing arena is lower cost, simplified scalability and quicker turnaround time; while the cold start of same requested functions becomes necessary trade off of FaaS.

Comparative Statistics

The investigation study based upon cloud application functionality and some non-functional requirements, an appropriate monolith, micro services, or server less model selects for each specific use case. These all are known as solution architecture for clients as per their needs. The comparison statistics of these three depicted in Table 1.

Table 1. Comparative Statistic

Architecture Type	Key feature	Functional Services	Drawbacks

Monolithic Cloud Hosting Architecture	Easy to develop, deploy and scale	Application that has different modules, where is no single developer understand entirely an application; examples ERP, CRM	High Maintenance, Difficulty to adopting new and advance technologies
Micro Service Cloud Architecture	Better deployment ability, Relatively small and productive , Improved fault isolation.	Application modules are independent of each other thus known independent deployment object's and can be scaled independently of other services. examples: Customer service Order service and Inventory service	Additional complexity, Testing is more difficult, Increased memory consumption
Server less Cloud Architecture	Automatic Scalability, Quick start, Pay-as you go model	Application modules can be broken down into single functions, and provides actionable results. Examples: Authentication, Notification, Event streaming	When not in use shut down, every new user demanding same functions again needs cold start

While choosing any of appropriate cloud paradigm; the advanced cloud architecture empowers to build and run scalable applications to meet the vision of cloud applications, encouraging the diverse applications facilities; their delivery and integration with IoT based use cases.

3. Cloud IoT

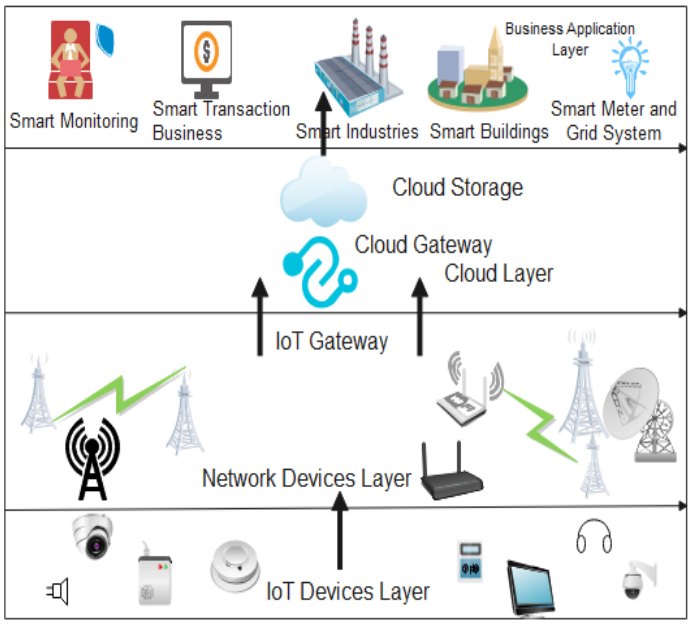
In this competitive edge; a pool of technology with minimum issues and challenges act as a communication facilitator. The integration of Cloud services with Internet of things provide such

pool which utilised in all over the world. This bilateral relationship provides numerous opportunities in this competitive edge. The countless application of IoT and generated data; its security and analytical accumulation through Cloud; led to open the doors of smart digital applications which will be part of smart living in next few years. The Cloud and integrated IoT platform provides a complete solution for storing, processing, analysing, and visualizing IoT data in real time to support improved operational efficiency of the network with high scalability. Thousands of IoT sensors collect data and passed to the master brain i.e. Cloud infrastructure for the data processing, intelligent commanding and smart data analytics to perform actions. Now a day data as well as IoT devices grows exponentially the data processing and commanding could take place locally rather than in the cloud via an internet connection; Known as "fog computing" or "edge computing", which makes a lot of sense for energy constraint sensor based IoT applications and make enabling computer paradigm for smart world. These new technologies within cloud had a remarkable impact on world, but also associated with several issues and challenges.

Cloud Computing and the IoT are two demanding technology creates ample of opportunities for business, industries, medical and many more versatile areas. It is a technology which becomes necessity of many enterprises due to its smartness [4]. IoT and Cloud Computing complimenting each other; but also has crucial differences between them and to use them efficiently when have effective technical solution separately, as well as together.

4. How does it work?

Cloud computing and IoT integration revolutionized the world; but it is very necessary to know how exactly they works with each other? In this network portfolio, many IoT sensors (dozens, hundreds or thousands) collect data and send it to cloud servers for analysis. This data analyzed and store as per the need of applications through different tools so that the faults and failures can be resolved; which is also an important aspect of this integration. Cloud IoT infrastructure also includes special servers and storage, when needed for real-time operations. The integrated Cloud IoT architecture is depicted in Figure 1.



For example, a smart city, smart factory, smart medical applications, smart transportation and many more areas taken the benefit from the cloud-based deployment of its IoT systems and applications. When these applications produce large amount of data Cloud services facilitates it in a cost-effective way.

5. Interoperability

The world is getting smaller and smaller as people connected through network computerized system and this can be possible when various software and hardware platform link up with each other is such a way that running applications become compatible with hardware and software. As the complexity of systems rises due to heterogeneous integration of software and hardware; a term interoperability come in to mind; those working with such systems in industries. IoT is also a platform where Interoperability is an important challenge.

In term of definition it can be defined as an ability to connect and communicate centrifugally; even the systems are different with each other. It automatically interprets the information exchanged meaningfully and accurately in order to produce accurate and useful results as expected by end users. Interoperability can have important economic consequences. The result leads to failure when the systems are not compatible and interoperable with each other in the cloud –IoT integration.

Interoperability & Cloud-IoT Integration

In 1988 or even earlier; the problem of interoperable systems has been considered. The two systems are said to be perfectly interoperable when they do not interfere the running applications in a common portfolio. ISO/IEC explains an interoperable unit are those that they share no or little knowledge of characteristics; when working with conjunction. IoT is composed of a variety of devices, and the inter communication between theses heterogeneous devices requires standard interoperability. A True IoT interoperability means all IoT devices and services use the same standardized IoT-Cloud Integration with four major interoperability concerns are:

- **Technical Interoperability**: During the communication establishment between IoT and cloud servers; the ability of cover technical aspects; called Technical Interoperability. It also includes transmission and communication protocols and data exchange rules that infrastructure needed.

- **Syntactic Interoperability**: Applications when running on different machines with different syntax; the ability to make the syntax universal; although systems are not aware the meaning of information exchanged; called Syntactic interoperable systems.

- **Semantic Interoperability**: Semantic interoperability refers the ability of systems that the meaning of written and shared syntax must be easily understanding; either the configuration and application services are different.

- **Organisational Interoperability:** Organisational interoperability defines rules where organization align their business processes, future results and expectations to achieve beneficial goals [11]. It requires relevant information exchanged in manner that aims to meet the requirements of the user community by making services easily available.

6. Literature Review

Although there are several work has been done in this direction, some specific to certain limited aspects of Cloud IoT integration and its interoperability are:

1. Luigi Atzori, Antonio Iera, Giacomo Morabito, elaborated and explains an IoT is a main enabling factor of paradigm and how its integration with another technologies performs?

2. Sfar AR, Zied C, Challal Y details the Concerned Issues and Challenges with respect to architecture and application domain.

3. Researchers of Paper 3 presented and reviewed the recent literature with respect to design and operation portfolio of wireless sensor-actuation systems. And a high energy Physical Layer proposal within architecture.

4. In the paper [4], Kutzias et all. Summarizes integration challenges of two technologies i.e. cloud and IoT; several existing Cloud and IoT architectures and a survey on existing integration challenges.

5. Taleb, Nasser & Mohamed, Elfadil. [5] reviewed literature shed light on future perspectives of Cloud-IoT technology and solutions of security and privacy risk through mobile cloud computing and cloud-computing governance.

6. Alem Čolaković, Mesud Hadžiali [6] provides insights brief view of issues and challenges; their technological solutions and some Novel research ideas to facilitates future research's.

7. This paper [7] performs a comprehensive survey on Interoperability; IoT and Cloud Integration challenges within interoperability concerned.

8. Pliatsios, Antonios & Goumopoulos, Christos & Kotis, Konstantinos. (2019) [8] briefly surveyed various solution perspectives of issues of interoperability in the IoT domain. Furthermore; illustrate an an approach as a solution to achieve interoperability in IoT systems that can lead to a "Social Network" of Things.

9. Researchers of paper [9] illustrates a comprehensive survey of different semantic interoperability solutions; and the pivotal semantic models. For this study they suggested some important tools and frameworks.

10. G. Yang et. all [10] illustrate challenges faced by internet of medical things, and how the real time data streaming take place using protocol stack.

11. Séverine Blanc-Serrier, Yves Ducq, Bruno Vallespir, [11] presented a architecture model of enterprise or industries; to work with effortless interoerable environment within integrated environment.

7. Research Objectives

The surveyed literature focuses on specific perspective interoperability study rather than common architecture perspective's. Thus the objective of study is in the reference of interoperability of Cloud-IoT Integrated platform are:

1. An ideal Cloud- IoT platform architecture deployment with Interoperability facility.

2. Study of the key concerning issues of interoperability and solution for these key issues in IoT ecosystems regarding different aspects.

3. Developed an Algorithm and work flow model as a solution for ideal Cloud-IoT Platform.

4. Study of various applications areas that supports and enhances performance using proposed cloud-IoT Interoperable environment.

8. Methodology

This study intends to use following methodologies and make some contributions:

1. Survey of literature for developing successful Interoperability Compatible Cloud-IoT architecture.
2. Researching and identifying the intrinsic and extrinsic motivations for developing Cloud-IoT solutions.

3. Proposal of Ideal Platform; Algorithmic approach with modular programming techniques for IoT Interoperability within Cloud-IoT Infrastructure.
4. Implementation of Proposed Model in versatile Application areas.

9. Conclusion

Addressing interoperability in IoT systems is a crucial key factor for IoT development. There is an urgent need to address the problem at all levels of IoT interoperability and to take into account the limitations of IoT systems. In this context, we will study the current developments on this issue, comparing the solutions of major research platforms. I also focus on the main open issues and challenges. Finally, I will have proposed to design and implement a framework/architecture that utilizes tools and methods that increase interoperability at all levels with the enabling technique of Cloud Computing i.e. Fog computing with following future research Scope:

- Communications between the Devices, Fog servers and the Cloud.
- Communications between Fog Servers and cloud.
- Integrating Computing Deployment issues and Challenges
- An Ideal Computation Algorithm.
- Implementation and simulation scenario with results.

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